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GB A 2145354	GB 1412836	GB 0849431
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GB 1528514		

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(54) Producing composite metal articles

(57) In producing a composite steel material, cylindrical steel elements (1) are first coated with nickel, manganese, copper or a combination thereof and then packed in a mild steel can (2) to produce a non-random arrangement of the elements (1) in the can (2) and wherein the packed can (2) is extruded to form a composite dual microphase billet in which fibres of martensite in the billet are completely surrounded by austenite. Flat plates can be used instead of cylindrical elements and the elements can be stacked alternately in mutually perpendicular arrays. Other metals used are niomonics titanium or maraging steel. The billet can be used for jet engine turbine blades, armour, helicopter rotor blades, car suspension stress parts or sword blades.

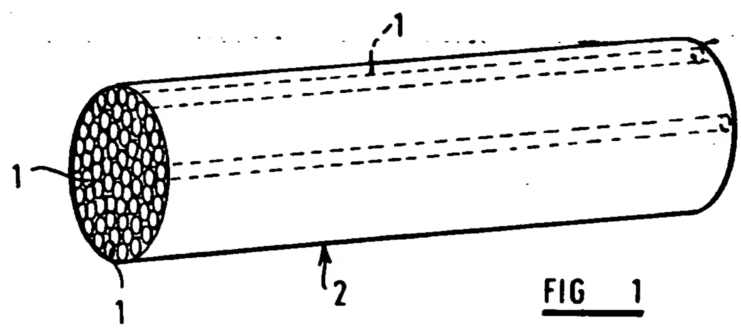

FIG 1

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The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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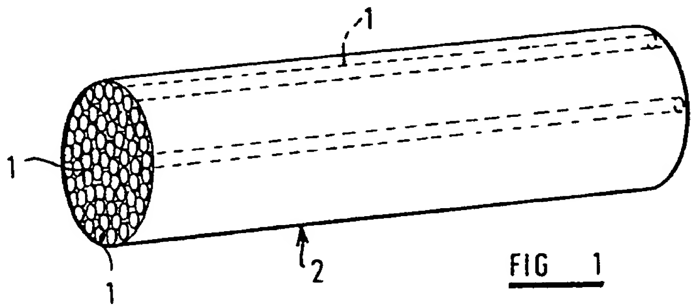

FIG 1

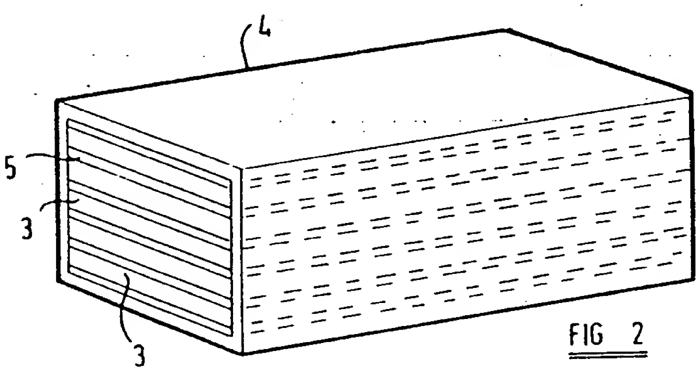

FIG 2

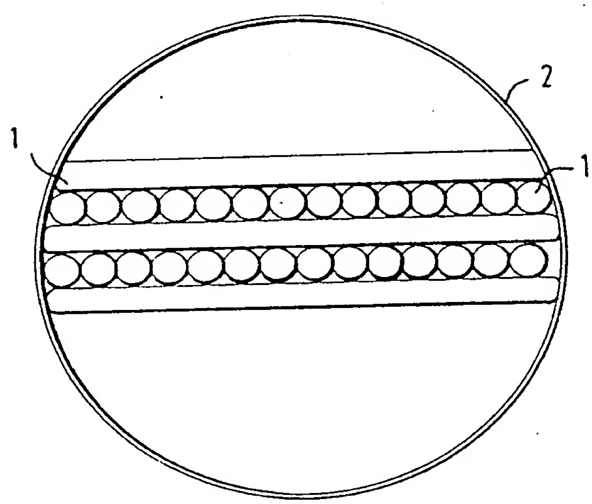

FIG 3

SPECIFICATION

Improvements in or relating to composite metal materials and uses thereof

This invention concerns improvements in or relating to composite metal materials and uses thereof. In particular, this invention relates to high strength steels and uses thereof.

The uses of ultra-high strength steels are limited by their high susceptibility to stress corrosion cracking. Although progress has been made in increasing the fracture toughness of such steels, corresponding improvements in the threshold stress intensity factor of such steels have not be achieved.

It has now been proposed to develop steel having dual-phase microstructures in which the separate constituents are responsible for different properties of the steel. In particular, it has been proposed to produce a steel having islands of tempered martensite phase, which imparts the necessary strength properties, around which is a continuous network of stable austenite. The austenite acts as a mechanical crack arrestor and produces a steel with superior stress corrosion performance by reducing the effective stress intensity and hydrogen concentration at crack tips.

In a known method, the dual-phase microstructure steel is formed by coating high strength steel particles with a layer of nickel. The particles employed are in the form of steel powder or bright drawn wire of 0.2 to 0.6mm in diameter chopped into 1mm length sections. The coated steel particles are washed and dried, packed into 75mm diameter mild steel cans, evacuated and finally sealed. The cans are then heat treated to approximately 1000°C and extruded to produce 2.5mm by 12.5mm rectangular section bars. This treatment results is a dual-phase microstructure in which a continuous layer of austenite surrounds each fibre of medium carbon martensite. The extruded material is heat-treated to cause austenization and is then oil-quenched. The quenched material is cooled to −196°C to ensure the transformation of any metastable austenite and is finally tempered.

In the above-described method, the nickel plated steel particles are, of course, packed into the cans in an essentially random manner prior to heating and extrusion and therefore the process results in a final rod of dual-phase microstructure steel in which the steel particles are stretched out to form fibres of martensite, surrounded by austenite, which extend only a small distance along the final rod. Moreover, the above-described method has the particular disadvantage that, if the diameter of the mild steel can is increased, the eventual size of the martensite fibres becomes so small that the resulting material loses some, if not all, of its desired properties.

The above described method also produces only small quantities of steel and would not be suitable for large-scale production of steel. Moreover, the above-described method also requires the high strength steel to be reduced down to a very small wire diameter, which proves is difficult and expensive.

It is an object of the present invention to overcome or at least mitigate the disadvantages of the previously proposed method discussed above.

According to a first aspect of the present invention, there is provided a method of producing a composite metal material, comprising coating a plurality of elements of a first metal or metal composition with a second metal or metal composition and packing the coated elements into a metal or metal composition container to produce a non-random arrangement of the elements in the container to form a composite metal billet.

Usually the composite metal billet is extruded to form a reduced section billet. Preferably, the packed container is fitted with end caps, evacuated and sealed prior to extrusion. In one arrangement the elements each have an axis and are packed into the container so that the axis of the elements are parallel. Alternatively, when each element has an axis the elements may be packed in the container so that the axes of at least some of the elements extend in a first direction and the axes of at least some of the elements extend in a second direction different from the first direction. The second direction may be perpendicular to the first first direction.

Usually the container is cylindrical and the elements may also be cylindrical. Preferably, the elements and/or the container are/is of square, rectangular circular or hexagonal cross-section. Alternatively, the elements may be in the form of sheets of the first metal or metal composition and the container may then be of square or rectangular cross-section.

The first metal or metal composition may comprise hardenable steel, niomonics, maraging steel or titanium, while the elements may be coated with nickel, copper or manganese or any combination thereof. Normally, the elements are coated by plating or by wrapping the elements in a foil formed of the second metal or metal composition.

The present invention also provides, in a second aspect, a billet whenever produced by a method in accordance with the first aspect and a product whenever producted from such a billet.

In a third aspect, the present invention provides a method of producing a sword blade using a method in accordance with the first aspect, comprising inserting a guide member into the elements packed in the container before extruding the container and using the reduced section billet formed by the extrusion to forge the blade so that the guide member provides a path for signals passing from one

end of the finished blade to he other end thereof. Generally, the guide member comprises a ceramic element, an insulated electrically conductive element or a light guide.

The invention also provides a sword blade whenever produced using a method in accordance with the first or third aspect or using a billet in accordance with the second aspect and a sword whenever incorporating such a blade.

For a better understanding of the present invention, and to show how the same may be put into effect, reference will now be made, by way of example, to the accompanying drawing, in which:

Figure 1 illustrates one arrangement for packing coated metal elements in a can for use in a method embodying the invention;

Figure 2 illustrates one arrangement in accordance with the invention for forming a hard steel billet from metal sheet;

Figure 3 illustrates an alterative arrangement for packing coated metal elements in a can for use in a method embodying the invention.

Referring now to Fig. 1, a plurality of cylindrical elements of hardenable metal or metal alloy, for example EN 47 steel, are coated with approximately 5% by volume of nickel by either plating the elements or wrapping them in a nickel foil. The coated elements 1 are then stacked in an ordered, non-random arrangement in a thin wall metal container or can 2 which, for example, may be made of mild steel, so as to extend parallel one to another as shown in Fig. 1. The elements 1 are conveniently of 6mm square cross-section and are of the same length as the can, for example, 200mm. The elements, can of course, be of any other cross-sectional shape for example such as square or hexagonal. The can may be approximately 100kmm to 300 mm in diameter.

After the coated elements 1 have been packed into the can 2, the open end of the can is selaed with an end cap and the can 2 is evacuated to prevent oxidation occuring on the surface of the rods during the following processes and then sealed. The resulting billet is reduced in size to the cross-sectional dimensions of an original element, for example 6mm by 6mm, or to any other suitable dimensions depending upon the intended use of the finished rod. This reduction of the billet may be performed by hot forging extrusion, rolling, drawing or any other suitable technique or any combination of suitable techniques.

In one preferred embodiment of the invention, the can 2 is cylindrical and of circular cross-section, being approximately 150mm in diameter. When fully packed the can contains 1600 elements 1 of 3mm square cross-section. The can 1 is then extruded to 48 mm diameter, rolled down to 10mm diameter and drawn to form a square 6mm×6mmrod. The drawn rod may be quenched and tempered in the usual way.

The size of the starting elements 1 will, of course, be dictated by the required cross-section of the fibres (martensite fibres where the elements are made of hard steel) in each finished rod of hardenable material. This can be calculated by considering the finished size of the component and the starting size of the can. Thus, if the diameter of the can 2 is increased to 300mm, the cross-section of the elements could be increased to 6mm×6mm.

The nickel covering applied to the elements forms a tough austenite phase in the steel which reduces the effective stress intensity and hydrogen concentration at the top of any crack trying to propogate through the material. It is envisaged that coatings of materials other than nickel could be used to provide the same effect, for example, manganese or copper may be used or any combination of these materials, such as a nickel and manganese combination.

Although, in the arrangement described above, the elements are all packed in the can 2 so as to be substantially parallel to the longidutinal axis of the can, the elements may be arranged in more than one direction, as shown in Fig. 3, for example, so as to give crack protection in a longitudinal direction or desired combination of directions. In fact any non-random arrangement of the elements could be used.

Moreover, the elements 1 may be replaced by metal sheets 3 (Fig. 2), for example hard steel sheets, which are either plated with nickel or interleaved with nickel foil. In such a case, the metal sheets coated with nickel or interleaved with nickel foil 5 are stacked in a square can 4 which is the evacuated and sealed as described above. In such an arrangement, it would be convenient to reduce the billet by rolling, although, of course, any of the methods described above which are suitable could be used.

A hardenable metal rod produced by the above described method is particularly suited to use in sword blades, for example, fencing blades or other components which may be subjected to sudden stresses.

Thus, the steel is almost identical to normal steel in weight and so, to a fencer, a blade made from the steel will feel like a conventional blade. Further, if a crack does develop from a surface defect, for example from a nick caused by banging another blade, or from overstressing when the blade is again stressed, the crack has great difficulty in travelling through the blade. Further, it has been found on small test samples that the sudden application of stress to the material causes crack propagation but as the stress level drops, the crack is deflected parallel to the axis of the blade. Thus, although the blade is no longer usuable, it remains intact. Accordingly, the use of this material would help

avoid the accidents and deaths which have occured when a blade has been broken leaving an unprotected end of very small cross-sectional area.

In particular, the above-described method lends itself to the production of fencing blades in which electric hit detection is provided. In such blades, it is at present necessary to form a slot approximately 0.7mm wide and 1mm deep along the length of the blade to receive an insulated metal wire to connect the point of the fencing blade to the guard or handle. With material embodying the present invention the need to form a slot in the finished blade could be obviated. In particular, a ceramic, glass or insulated copper rod could be inserted in the centre of the can prior to extrusion thereof, to afford an alternative means of transmitting a signal along the blade. Such a blade should be more simple to manufacture than conventional blades and should be safer to use.

Further, insertion of an element or number of elements (or sheets) of a different material to the hardenable material, would not noticeably effect the bulk properties of the finished hardenable material but would allow easy identification of the finished material under a microscope for quality and control purposes, particularly where more than one quality of material is being produced.

The finished material may also be suitable for use on the construction of jet engine turbine blades, especially for the outside fan blades of the engine. Other possible uses of the finished material would include protection against projectiles such as bullets, and any component where it is desirable to avoid catastrophic failure, such as helicopter rotor blades or the stress parts in a car suspension system, or any components subject to a corrosive environment.

The finished product is resistant to crack propagation due to stress and corrosive environments because, in case of a hard steel material produced by the above method, the austenite surrounding the martensite, because of its inherent toughness, reduces effective stress at the advancing crack tip and shields the crack tip from corrosive environments.

The above described methods can be used to produce composite metal materials formed from hardenable metals or metal alloys other than steel, for example niomonics, maraging steel or titanium. Also, the nickel covering or plating may be replaced by, for example, a copper or a manganese coating or a coating formed from any combination of nickel, copper and manganese, for example a nickel-manganese alloy.

CLAIMS

1. A method of producing a composite metal material, comprising coating a plurality of elements of a first metal or metal composition with a second metal or metal composition and packing the coated elements into a metal or metal composition container to produce a non-random arrangement of the elements in the container to form a composite metal billet.

2. A method according Claim 1, further comprising extruding the composite metal billet to form a reduced cross section billet.

3. A method according to Claim 2, wherein the packed container is evacuated and sealed prior to extrusion.

4. A method according to claim 1, 2 or 3, wherein the elements each have an axis and are packed into the container so that the axes of the elements are parallel.

5. A method according to Claim 4, wherein each element extends along substantially the entire length of an axis of the container when the elements are packed in the container.

6. A method according to claim 1, 2 or 3, wherein each element has an axis and the elements are packed in the container so that the axes of at least some of the elements extend in a first direction and the axes of at least some of the elements extend in a second direction different from the first direction.

7. A method according to Claim 6, wherein the first and second directions are perpendicular.

8. A method according to any preceding claim wherein the container is cylindrical.

9. A method according to any preceding claim wherein the elements are cylindrical.

10. A method according to claim 8 or 9, wherein the elements and/or the container are/is of square, rectangular circular or hexagonal cross-section.

11. A method according to any one of claims 1 to 8, wherein the elements are in the form of sheets of the first metal or metal composition.

12. A method according to claim 11 when dependent on Claim 8, wherein the container is of square or rectangular cross-section.

13. A method according to any preceding claim, wherein the first metal or metal composition comprises steel, niomonics, maraging steel or titanium.

14. A method according to any preceding claim, wherein the elements are coated by plating or by wrapping the elements in a foil formed of the second metal or metal composition.

15. A method according to any preceding claim, wherein the elements are coated with nickel, copper or manganese or any combination thereof.

16. A method of producing a composite metal material substantially as hereinbefore described with reference to Fig. 1, 2 or 3 of the accompanying drawing.

17. A billet whenever produced by a method in accordance with any one of the preceding claims.

18. A product whenever produced from a billet in accordance with Claim 17.

19. A method of producing a sword blade using a method in accordance with Claim 2 or anyone of claims 3 to 16 when dependent on Claim 2, comprising inserting a guide member into the elements packed in the container before extruding the container and using the reduced section billet formed by the extrusion to forge the blade, so that the guide member provides a path for signals passing from one end of the finished blade to the other end thereof.

20. A method according to Claim 19, where the guide member comprises a ceramic element, an insulated electrically conductive element or a light guide.

21. A sword blade whenever produced using a method in accordance with any one of claims 1 to 16, 19 or 20 or using a billet in accordance with Claim 17.

22. A sword whenever incorporating a blade in accordance with Claim 21.

23. Any novel feature or combination of features described herein.

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